
UNIVERSITI PUTRA MALAYSIA

# REMOVAL OF COPPER AND LEAD FROM AQUEOUS SOLUTION BY TARTARIC ACID MODIFIED RICE HUSK

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MASTER OF SCIENCE
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# REMOVAL OF COPPER AND LEAD FROM AQUEOUS SOLUTION BY TARTARIC ACID MODIFIED RICE HUSK

By

WONG KOI KIM

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Science in the Faculty of Science and Environmental Studies
Universiti Putra Malaysia

February 2001

**I would like to dedicate this thesis to:**

**My Family Members,**

**My Supervisor,**

**My Co-supervisors,**

**My Friends,**

**All of those who were involved in this study…**

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia
in fulfilment of the requirement for the degree of Master of Science

# REMOVAL OF COPPER AND LEAD FROM AQUEOUS SOLUTION BY TARTARIC ACID MODIFIED RICE HUSK

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**Chairman : Prof. Dr. Lee Chnoong Kheng**

**Faculty : Science and Environmental Studies**

The potential of rice husk (RH) modified with various carboxylic acids to remove Cu(II) from aqueous solution was investigated. It was found that the sorption capacity of rice husk was enhanced by this modification. Tartaric acid modified rice husk (TARH) has the highest sorption capacity for Cu(II). TARH was produced by treating RH with 1.2 M tartaric acid and heated at 180 °C for 10 minutes.

In order to understand the sorption characteristics of Cu(II) and Pb(II) by TARH, batch and column studies were performed under various experimental conditions. The parameters studied were pH, temperature, contact time, initial concentration of metal solutions, presence of competitive cations and chelators, sorbent dosage, rate of agitation, particle size of sorbent, bed height, flow rate and sorption-desorption cycles using synthetic solution and semiconductor electroplating wastewater.

The results of batch studies indicated that the sorption process was pH dependent and exothermic. Kinetic study showed that uptake of Cu(II) and Pb(II) reached equilibrium after 60 minutes. The maximum binding capacities of the TARH at room temperature determined from the Langmuir isotherms were 31.85 and 120.48 mg/g for Cu(II) and Pb(II), respectively. In the presence of competitive cations and chelators, metal uptake decreased. The affinity of TARH for Pb(II) was greater than Cu(II) on a weight basis. The uptake increased with increasing sorbent dosage and agitation rate.

The results of column studies showed that the utilised capacities of TARH at different bed depths agreed closely with the maximum sorption capacities obtained from Langmuir isotherm for both Cu(II) and Pb(II). The results also showed that breakthrough depended on bed depth, initial influent concentration of metal ion and flow rate. However, the effect of flow rate on sorption was minimal. The relationship between service time and bed depth was linear. Predicted breakthrough curves obtained from a two parameter mathematical model for Cu(II) and Pb(II) in wastewater agreed well with experimental values.

In sorption-desorption study, Cu(II) and Pb(II) could be removed almost quantitatively by eluting with a 0.1 M HCl solution and the column could be used repeatedly for at least 5 cycles in the treatment of wastewater.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

# PENYINGKIRAN KUPRUM DAN PLUMBUM DARIPADA LARUTAN AKUEUS OLEH SEKAM PADI YANG DIUBAHSUAIKAN DENGAN ASID TARTARIK


Oleh

**WONG KOI KIM**


**Februari 2001**


**Pengerusi : Prof. Dr. Lee Chnoong Kheng**

**Fakulti : Sains dan Pengajian Alam Sekitar**



Keupayaan sekam padi (RH) yang diubahsuaikan dengan pelbagai jenis asid karbosilik untuk mengasingkan Cu(II) dari larutan akueus telah dikaji. Didapati bahawa pengubahsuaian ini telah meningkatkan kapasiti erapan sekam padi. Sekam padi yang diubahsuaikan dengan asid tartarik (TARH) memberi erapan yang paling tinggi. TARH telah disediakan pada keadaan optimum dengan merawat RH menggunakan 1.2 M asid tartarik dan dipanaskan pada 180°C selama 10 minit.

Untuk memahami ciri-ciri erapan TARH terhadap Cu(II) and Pb(II), kajian kelompok dan turus telah dijalankan di bawah pelbagai kaadaan eksperimen seperti pH, suhu, masa, kepekatan awal larutan akueus logam, kehadiran kation-kation saingan dan agen-agen pengkelat, dos pengerap, kadar acuman, saiz zarah, ketinggian turus, kadar aliran dan edaran erapan-penyaherapan dengan menggunakan larutan sintetik dan air sisa saduran semikonduktor.

Keputusan kajian kelompok menunjukkan bahawa proses erapan dipengaruhi oleh pH dan bersifat eksotermik. Kajian kinetik menunjukkan keseimbangan tindakbalas untuk Cu(II) and Pb(II) diperolehi selepas 60 minit. Kapasiti erapan maksimum untuk TARH terhadap Cu(II) dan Pb(II) pada suhu bilik yang ditentukan daripada isoterma Langmuir adalah 31.85 dan 120.48 mg/g masing-masing. Kehadiran kation-kation saingan dan agen-agen pengkelat mengurangkan erapan logam. Affiniti TARH terhadap Pb(II) lebih tinggi daripada Cu(II) berdasarkan berat. Erapan meningkat dengan peningkatan dos pengerap dan kadar acuman.

Keputusan kajian turus menunjukkan bahawa kapasiti erapan TARH yang digunakan untuk mengerap Cu(II) dan Pb(II) pada pelbagai tinggi turus adalah lebih kurang sama dengan kapasiti erapan maksimum yang diperolehi daripada isoterma Langmuir. Keputusan juga menunjukkan bahawa masa pemunculan dipengaruhi oleh ketinggian turus, kepekatan awal influen dan kadar aliran. Walau bagaimana pun, kesan kadar aliran terhadap erapan adalah kecil. Hubungan di antara masa layangan dan ketinggian turus adalah linear. Kelok pemunculan bagi Cu(II) dan Pb(II) dari air sisa yang diramalkan daripada model matematik dua parameter adalah lebih kurang sama dengan nilai eksperimen.

Dalam kajian erapan-penyaherapan, hampir semua Cu(II) dan Pb(II) dapat diasingkan dengan larutan 0.1 M HCl dan turus tersebut dapat digunakan sekurang-kurangnya 5 kitaran secara berterusan untuk merawat air sisa.

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Last but not least, I would like to express my deepest affection to my beloved family for their caring, patience, support and understanding.

I certify that an Examination Committee met on 16th February 2001 to conduct the final examination of Wong Koi Kim on his Master of Science thesis entitled "Removal of Copper and Lead from Aqueous Solution by Tartaric Acid Modified Rice Husk" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. The Committee Members for the candidate are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I declare that this thesis has not been previously or concurrently submitted for any other degree at UPM or other institutions.

(Wong Koi Kim)

Date: 21st February 2001

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| | |
|---|---|
| b | constant related to the energy of sorption |
| $\beta_L$ | liquid-solid mass transfer coefficient |
| $C_e$ | equilibrium concentration of metal ion |
| $C_o$ | initial metal ion concentration in solution |
| $C_t$ | metal ion concentration in solution at time t |
| erf(x) | error function of x |
| H | bed depth |
| $\Delta H°$ | enthalpy change |
| k | initial sorption rate |
| $k_1$ | a constant. |
| $k_2$ | a constant. |
| $k_3$ | a constant. |
| $k_4$ | a constant. |
| $k_r$ | rate constant of sorption |
| $k_L$ | Langmuir isotherm constant |
| $K_d$ | distribution coefficient |
| $K_i$ | intraparticle diffusion rate constant |
| log $K_1$ | stability constant which show the effectiveness of a chelator |
| L | column length |
| m | mass of sorbent per unit volume of metal ion solution |
| M | sorbent weight |
| $N_e$ | amount of metal ion sorbed by sorbent at equilibrium |

| | |
|---|---|
| $N^*$ | maximum sorption of the system |
| $N_o$ | sorption capacity |
| $q_e$ | amount of metal ion sorbed on the surface of the sorbent at equilibrium |
| $q_t$ | amount of metal ion on the surface of the sorbent at time t |
| Q | flow rate |
| $R^2$ | correlation coefficient |
| R | gas constant |
| $\sigma$ | standard deviation |
| S | surface area for mass transfer or specific particle surface |
| $\Delta S°$ | entropy change |
| t | time |
| $t_{0.5}$ | time at 50 % breakthrough |
| T | absolute temperature |
| v | volume of particle free liquid |
| $\nu$ | linear flow rate |
| w | mass of sorbent |

# CHAPTER I

## INTRODUCTION

Wastewater is the combination of liquid and water-transported wastes from homes, commercial buildings, industrial facilities, and institutions, along with any groundwater infiltration, surface water and storm water inflow that may enter the sewer system. Wastewater may contain pollutants such as heavy metals, toxic organic compounds, phosphorus, detergents, biodegradable organics, nutrients, dissolved inorganic solids, and refractory organics.

Heavy metal is one of the pollutants present in wastewater and can directly endanger plants, animals and human life. There is a growing awareness of the potential health hazard presented by the accumulation of heavy metals in various aspects of the environment. Heavy metals are generally classified as hazardous materials. Any cation having an atomic weight greater than 23 (atomic weight of sodium) is considered a heavy metal (Corbitt, 1998); hence wastewater obviously contains numerous types of heavy metals. As many heavy metals can be toxic and carcinogenic, it is important to investigate the type and level of metals in wastewater.

The most toxic heavy metals are mercury, lead, arsenic, chromium, cadmium and nickel. These metals are widely used in industry, particularly in metal finishing or metal plating industries and in such products as batteries and electronic devices. They are also used in certain pesticides and medicines. Thus heavy metals enter the